Fisher & Paykel
HEALTHCARE

TECHNICAL MANUAL

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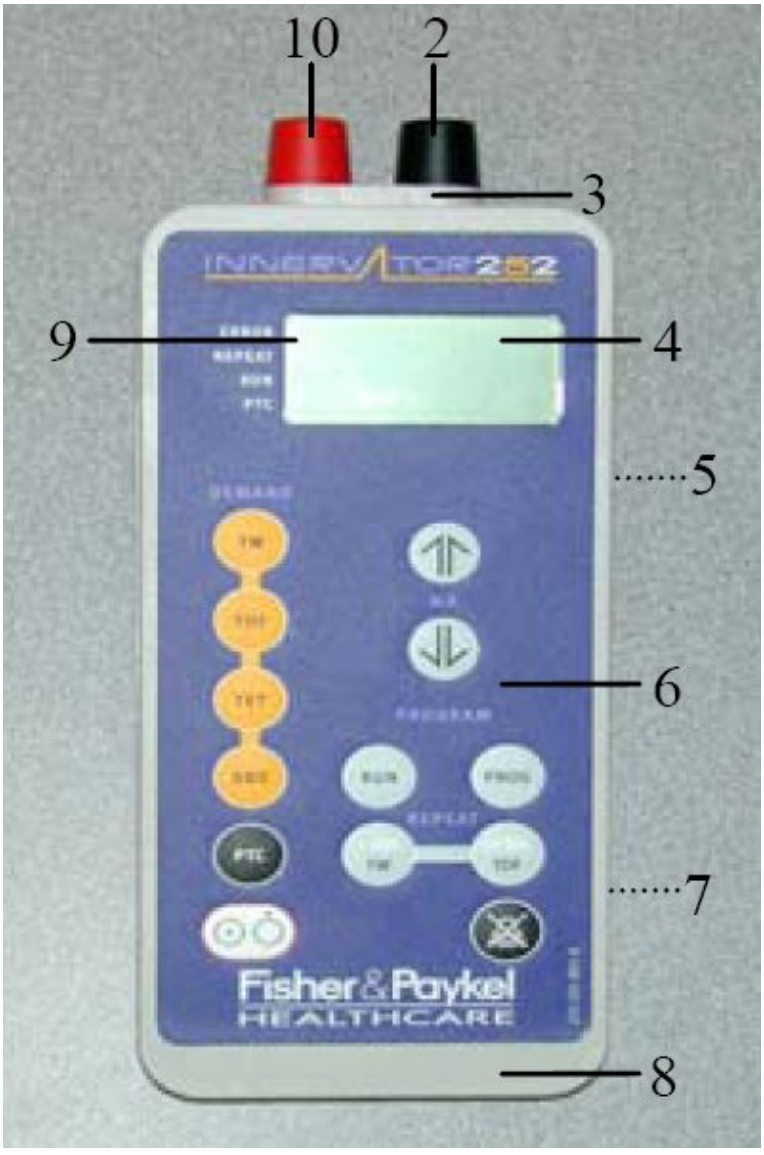

Fisher & Paykel
HEALTHCARE

TECHNICAL MANUAL

NS232

NS242

NS252

NS272

CONSTANT CURRENT PERIPHERAL NERVE STIMULATOR AND NERVE LOCATOR

Revision I

By I.H

December 2005

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Part Number 185 040 670, Revision I, Issued December 2005

Technical Manual for Nerve Stimulator models: NS272, NS242, NS252 (V2.0, V1.0 & 1.1)
Technical Manual for Nerve Locator models: NS232 (V2.0)

Note: if the unit is an NS242 with serial number smaller than 031202001629 or an NS252 with serial number smaller than 031202001627, refer to NS252/242 V1.0 & V1.1 Software Technical Manual on page 26

Fisher & Paykel Healthcare have a policy of continued product improvement and reserve the right to alter specifications without notice

Changes made to this technical manual

Wheelie bin symbol added

Maximum voltage in both internal and external mode are better defined

Separate Set Current Offset and Alarm Limits back to the format as per revision G

Include Technical Manual for NS242 and NS252 with V1.0/1.1 Software

TABLE OF CONTENTS

INTRODUCTION 6

1 GENERAL SPECIFICATIONS – V2.0 8

1.1 General Product Information (For All Nerve Stim Types) 8
1.2 External Mode Electrical Specifications (NS272 & NS252) 8
1.3 External Mode Electrical Specifications (NS242 only) 9
1.4 Internal Mode Electrical Specifications (NS272 & NS232) 9
1.5 Pulse Types 10

2 HARDWARE DESCRIPTION - V2.0 11

2.1 Control (For All Types) 11
2.2 Supply Rails (For All Types) 11
2.3 Low Battery Detect (For All Types) 11
2.4 Beeper (For All Types) 12
2.5 High Voltage Rail (NS272, NS252 & NS242) 12
2.6 Internal Mode Constant Current Controller (NS272 & NS232) 12
2.7 Internal Mode Leadset Monitor (NS272 & NS232) 12
2.8 External Mode Constant Current Controller (NS272, NS252 & NS242) 12

3 TEST POINTS (TP) - V2.0 14

3.1 For All Types 14
3.2 For NS272, NS252 & NS242 14

4 SELF TEST - V2.0 15

4.1 ROM Test (For All Types) 15
4.2 Display Test* (For All Types) 15
4.3 Model Test (For All Types) 15
4.4 Button Test (For All Types) 15
4.5 Internal Mode Current Test (NS272 & NS232) 16
4.6 External Mode Current Test (NS272, NS252 & NS242) 16

5 ERROR CODES - V2.0 17

6 SERVICE INFORMATION (FOR ALL TYPES) - V2.0 18

7 PART LIST - V2.0 19

7.1 For All Types 19
7.2 For NS272, NS252 & NS242 19
7.3 For NS232 only 19

8 ACCESSORIES - V2.0 20

8.1 For All Types 20

8.2 For NS272, NS252 & NS242 20
8.3 For NS272, NS232 20
8.4 Component Layout Diagram 21

APPENDIX A PRODUCT CHANGE HISTORY (FOR NS272, NS252, NS242) - V2.0 22

APPENDIX B PRODUCT NUMBERS (FOR ALL TYPES) - V2.0 23

B1. Model Number Explanation 23
B2. Serial Number Explanation 23
B3. Product Code Table 24

1 GENERAL SPECIFICATIONS – V1.0/V1.1 26

1.1 Electrical Specifications – V1.0/1.1 26
1.2 Pulse Types: ROM 999630013 26
1.3 Pulse Types: ROM 367020009 27

2 HARDWARE DESCRIPTION – V1.0/1.1 28

2.1 Control 28
2.2 Reference Rail 28
2.3 High Voltage Rail 28
2.4 Constant Current Control 28
2.5 Low Battery Detect 28
2.6 Miscellaneous 29

3 OPERATIONAL DESCRIPTION – V1.0/1.1 30

3.1 Power Down 30
3.2 Self Calibration 30
3.3 Pulse Delivery 30

4 TEST POINTS – V1.0/1.1 31

5 SELF TEST – V1.0/1.1 32

5.1 ROM 999630013 32
5.2 ROM 367020009 33

6 SERVICE INFORMATION – V1.0/1.1 34

7 PARTS LIST – V1.0/1.1 35

8 ACCESSORIES – V1.0/1.1 36

8.1 Component Layout Diagram 36

APPENDIX A SERVICE NOTE – V1.0/1.1 37

APPENDIX B PRODUCT CHANGE HISTORY – V1.0/1.1 38

APPENDIX C PRODUCT NUMBERS – V1.0/1.1 39

C1. Model Number And Serial Number Explanation 39
C2. Product Code Table 40

INTRODUCTION

Read the operating manual carefully before operating the unit.

Electrostatic sensitive devices

Type BF Equipment (IEC Standard).

(EU WEEE Standard) Do not throw away. See distributor for appropriate disposal for electrical and electronic components

Caution Dangerous high voltages may exist within this device for up to 1 minute after removal of batteries. The microprocessor may continue to run for up to 10 minutes after removal of batteries. It is recommended that the batteries be removed at least 10 minutes prior to disassembly.

Caution This device contains CMOS and other components which are sensitive to static charges. It is recommended appropriate procedures be followed for disassembly and service.

Caution An explosion is possible if used in the presence of flammable anaesthetics. An explosion may be caused by an arc which could occur if the electrodes come into direct contact as a pulse is being delivered.

Warning In External Mode, this device is to be used with non-invasive electrodes only. If needle electrodes are used in External Mode, localised tissue burning and excessive patient discomfort may result.

TECHNICAL MANUAL

NS232

NS242

NS252

NS272

Version 2.0

CONSTANT CURRENT PERIPHERAL NERVE STIMULATOR AND NERVE LOCATOR

1 GENERAL SPECIFICATIONS – V2.0

This part of the manual defines the technical specifications for the NS252 & NS242 Peripheral Nerve Stimulator, NS272 Peripheral Nerve Stimulator & Nerve Locator and NS232 Nerve Locator with version 2.0 software. Refer to the Operating Manual for NS272, NS252, NS242 and NS232 for detailed instructions on how to use the unit.

Any NS242 unit with a serial number smaller than 031202001629 runs on version 1.0 or 1.1 software. Any NS252 unit with a serial number smaller than 031202001627 runs on version 1.0 or 1.1 software. Please refer to the sections from page 26 onwards, for the technical specification.

1.1 GENERAL PRODUCT INFORMATION (FOR ALL NERVE STIM TYPES)

Battery Type:	3 times 1.5 V AA type alkaline cells (IEC type LR6)
Battery Life:	Up to 160 hours continuous use with alkaline batteries Note: This figure varies greatly depending on choice of External or Internal Mode in NS272, waveforms used and current delivered.
	Up to 160 hours continuous use with alkaline batteries in NS232, NS242, NS252
Operating Temperature Range:	0 °C to 35 °C
Operating Humidity Range:	0% RH to 65% RH
Storage Temperature Range:	-25 °C to +40 °C
Storage Humidity Range:	0% RH to 85% RH
Dimensions:	NS232:
	Height = 167 mm, width = 73 mm, depth = 43 mm
	NS242, NS252 and NS272
	Height = 175 mm, width = 73 mm, depth = 43 mm
Weight:	255g (185g without batteries)

1.2 EXTERNAL MODE ELECTRICAL SPECIFICATIONS (NS272 & NS252)

Output Current Range:	0 to 160 mA
Output Current Steps	5 or 10 mA (programmable)
Tetanus Frequency	50 or 100 Hz ± 10% (programmable)
Output Pulse Type:	Square, monophasic, constant current, unidirectional
Output Pulse Width:	195 ± 5 µs
Output Pulse Rise Time:	< 10 µs max (resistive load)
Output Pulse Fall Time:	< 10 µs max (resistive load)
Maximum Internal Voltage:	420 ± 10% V
Maximum Output Voltage:	350 ± 10% V
Maximum Load Impedance	For TW, TOF, TET, PTC, DBS
80 mA	4 kΩ
160 mA	1.8 kΩ
	(figures may vary depending on battery condition)
Set Current Offset:	
0 to 80 mA	± 2.5 mA
85 to 160mA	± 5.0 mA
Alarm Limits:	± 2.5 mA of the set current
Default Program:	10 s twitch

Default Program Settings:	
Tetanus Frequency	50 Hz
Maximum Current	80 mA
Current Steps	10 mA
DBS Pattern	3.3

1.3 EXTERNAL MODE ELECTRICAL SPECIFICATIONS (NS242 ONLY)

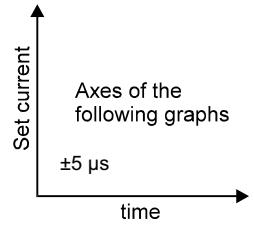
Output Current Range:	0 to 80 mA
Output Pulse Type:	Square, monophasic, constant current, unidirectional
Output Pulse Width:	195 ± 5 µs
Output Pulse Rise Time:	< 10 µs max (resistive load)
Output Pulse Fall Time:	< 10 µs max (resistive load)
Maximum Internal Voltage:	420 ± 10% V
Maximum Output Voltage:	350 ± 10% V
Maximum Load Impedance	For TW, TOF, TET
80 mA	4 kΩ (figures may vary depending on battery condition)
Set Current Offset	
0 to 80 mA	± 2.5 mA
Alarm Limits:	± 2.5 mA of the set current
Default Program Settings:	
Tetanus Frequency	50 Hz
Maximum Current	80 mA
Current Steps	10 mA

Note: The above specifications can not be guaranteed if the unit is used with a load impedance of more than 5 kΩ.

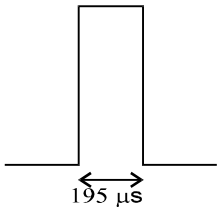
1.4 INTERNAL MODE ELECTRICAL SPECIFICATIONS (NS272 & NS232)

Output Current Range:	0 to 10 mA
Output Current Steps:	0.2 mA between 0.0 and 2.0 mA 0.5 mA between 2.0 and 5.0 mA 1.0 mA between 5.0 and 10.0 mA
Output Pulse Type:	Square wave, monophasic, constant current, unidirectional
Output Pulse Width:	195 µs ± 5 µs
Output Pulse Rise Time:	< 10 µs max (resistive load)
Output Pulse Fall Time:	< 10 µs max (resistive load)
Maximum Internal Voltage:	15 V ± 10%
Maximum Output Voltage:	10 V ± 10%
Maximum Load Impedance at 10.0 mA:	1.0 kΩ
Set Current Offset:	
For 0 - 2.0 mA:	± 0.15 mA
For 2.5 - 10.0 mA:	± 0.3 mA
Alarm Limits:	± 0.1 mA of the set current
Default Program:	10 s twitch

1.5 PULSE TYPES

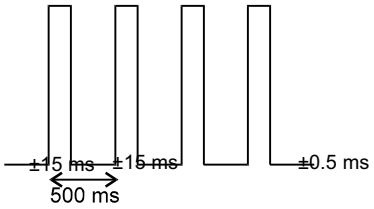


Twitch



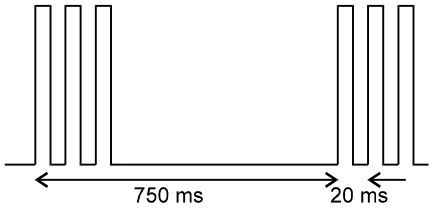
(All Types)

Train of four



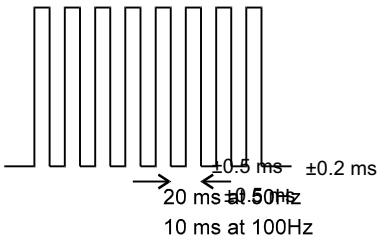
(NS272, NS252, NS242)

Double burst



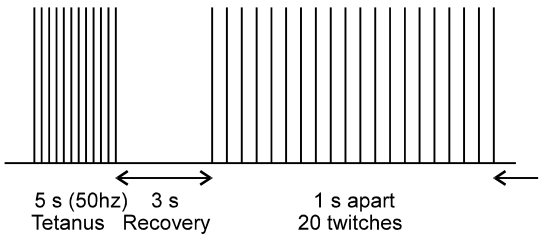
(NS272 & NS252 only)

Tetanus



(NS272, NS252) & (NS242 with 20ms at 50Hz only)

Post tetanic count



(NS272 & NS252 only)

2 HARDWARE DESCRIPTION - V2.0

2.1 CONTROL (FOR ALL TYPES)

The core of the system is a masked ROM microprocessor, U6 which has an LCD Driver and 3 Counters/Timers on chip.

The On/Off Button, SW1, works by generating a short pulse at the reset input of U6 via C30.

The remainder of the push-buttons are arranged in a row/column scanning matrix. A diode-OR connection between the rows enables any button to bring the interrupt input of U6 low. The microprocessor is then able to determine exactly which button is being pressed by examining the status of the Port 0 outputs and the Port 2 inputs.

U6 communicates via an I²C bus serial interface to the two A/D and D/A converters, U1 and U3.

The system timing is based on a 10 ms count generated inside U6. This time base is available at TP14.

2.2 SUPPLY RAILS (FOR ALL TYPES)

There are four main DC Supply Rails: +VBAT, +VCC, +VREF and +VDD. The first three are derived directly from the battery while the last is under microprocessor control.

+VBAT This supply is the raw battery voltage and is used to supply the two switch mode power supplies for +VDD and the HV Rail.

+VCC This supply is isolated and derived from +VBAT via diode D14 and further smoothed to provide a more stable voltage for the microprocessor and A/D and D/A converter ICs.

+VREF This supply is maintained at 2.5 V by a three terminal regulator, U4 and is used as the LCD drive voltage and as the reference voltage for both the A/D and D/A converters.

+VDD This supply, nominally 15 V, is generated by a switch mode converter IC, U5 configured as a boost mode DC to DC converter. The relevant components are L1, D7 and C29. The switching frequency is determined by C26.

U5 acts to control the voltage at its VFB input at a level equal to its internal reference voltage of 1.31 V. Thus the voltage divider R37 and R39 determines the level of +VDD.

The microprocessor is able to turn U5 on by pulling its IC input high via Q20.

+VDD is used to power the CMOS logic and the two current controllers, to drive the two FETs and supply C4 from which the Internal Mode pulses are generated.

There is an additional supply of 4 V which is used by the current controllers. This supply is produced by amplifying +VREF and is available at pin 7 of U7.

2.3 LOW BATTERY DETECT (FOR ALL TYPES)

The low battery detect works in two stages. Stage one lights up the battery symbol on the LCD as a warning once the battery voltage falls to 3.3 V. Stage two shuts the microcontroller down at 2.9 V, leaving only the battery symbol on the LCD to indicate why the unit is off.

The microcontroller monitors the battery voltage in two different ways. The first is by using A/D channel 3 of U3 and the potential divider R35 and R36. The second way is by monitoring the state of the LBD output of U5. When the IC input of U5 is high, the LBD output of U5 goes low whenever its LBR input falls below its internal reference voltage of 1.31 V nominal.

The microcontroller first checks the state of the LBD output of U5. If it is low then the microcontroller will shut down and will cease to function further until the batteries are changed. The unit must be turned off and on for U6 to recognise this has occurred.

If the LBD output of U5 is high, the processor will go on to check the voltage at the LBR input of U5 using the A/D converter. If the voltage at the LBR point is too low the battery symbol will appear on the display.

2.4 BEEPER (FOR ALL TYPES)

LS1 is a piezoelectric loudspeaker. It is driven with an audio frequency square wave produced by an astable multivibrator, Q17 and Q18. That oscillator is turned on and off by the microcontroller via Q19.

2.5 HIGH VOLTAGE RAIL (NS272, NS252 & NS242)

The high voltage rail is an electrolytic capacitor, C11, which is charged up to generate External Mode pulses.

To charge the rail, U6 activates the oscillator U2, by pulling down its reset pin, causing output Q4 to switch at a frequency determined by R15, R16 and C8. Q9 drives the primary of transformer XFORM1. The voltage at the secondary is rectified to charge C11.

When high current pulses are delivered the high voltage rail is regulated to approximately 400 V by comparator U7B. The high voltage rail is monitored by the potential divider R19, R20 and R53 and compared with +VREF. When the voltage at pin 3 of U7 reaches 2.5 V, Q24 is switched on to remove the base drive from Q8 and the oscillator is turned off.

The microcontroller also monitors the voltage across C11 using A/D channel 2 of U3 and the potential divider of R19, R20 and R53. This allows U6 to establish whether the voltage on C11 has reached the lesser of 420 V or (set current x 5000 Ω) and provide some control of the high voltage rail.

2.6 INTERNAL MODE CONSTANT CURRENT CONTROLLER (NS272 & NS232)

In order to deliver an Internal Mode constant current pulse, C4 must first be charged up from +VDD through R10. The microcontroller monitors the voltage across C4 via the potential divider R3, R2 and A/D channel 2 of U1.

The microcontroller then sets the level of constant current to be delivered by setting a voltage at the output of the D/A converter of U1.

At the start of the pulse the microcontroller turns Q7 on and Q1 and Q2 off. Under those conditions, the voltage at the collector of Q6 will increase depending on the difference between the voltages at the emitters of Q6 and Q5. The Q6 collector voltage determines how much current the Darlington configuration of Q22 and Q4 conducts. The collector current of Q4 is the current delivered at the output and it develops a proportional voltage across R1. Thus the Q5, Q6 pair maintains the output current equal to the voltage at the output of the D/A converter divided by the resistance of R1.

A/D channel 0 of U1 monitors the voltage across R1. By doing this, U6 is able to determine whether the correct current is being delivered at all times.

Q2 holds Q22 and Q4 in their off-state between pulses and while the unit is switched off, to avoid any output leakage currents.

2.7 INTERNAL MODE LEADSET MONITOR (NS272 & NS232)

The microcontroller is able to determine whether the Internal Mode leadset is connected to the unit by monitoring the voltage at A/D channel 3 input of U1.

2.8 EXTERNAL MODE CONSTANT CURRENT CONTROLLER (NS272, NS252 & NS242)

An External Mode pulse is generated in a similar way to the Internal Mode pulse.

In order to deliver an External Mode constant current pulse, C11 must first be charged up. The microcontroller monitors the voltage across C11 via the potential divider R19, R20, R53 and A/D channel 2 of U3.

The microcontroller then sets the level of constant current to be delivered by setting a voltage at the output of the D/A converter of U3.

At the start of the pulse the microcontroller turns Q12 and Q16 on and Q3 and Q11 off. Under these conditions, the voltage at the collector of Q15 will increase depending on the difference between the voltages at the emitters of Q15 and Q14. The Q15 collector voltage determines how much current Q10 conducts. The drain current of Q10 is the current delivered at the output and it develops a proportional voltage across R21. Thus the Q14, Q15 pair maintains the output current equal to the voltage at the output of the D/A converter divided by the resistance of R21.

A/D channel 0 of U3 monitors the voltage across R21. By doing this, U6 is able to determine whether the correct current is being delivered at all times.

External Mode current delivery is calibrated by selection of the current sense resistor R21. This resistor is selected during production testing and does not need to be checked. R21 will be one of the following values: 13.0Ω, 13.3 Ω or 13.7 Ω.

Q12 is used to prevent current leakage through Q10 at high C11 voltages. R23 acts to limit short circuit current and in conjunction with C16 limits damaging dv/dt to the FET Q10.

Q3 in series with Q13 holds Q10 in its off-state between pulses and for a short period after the unit is switched off to avoid any output leakage currents.

While the unit is switched on a 100 Hz signal is applied to the base of Q21 which keeps C39 charged and Q13 on. Approximately 1 minute after the unit is switched off C39 discharges and Q13 switches off allowing Q10 to switch back on. By this time the high voltage rail has completely discharged and no leakage current can flow.

When Q13 turns off, Q23 also switches off, removing the supply to U7 and conserving battery life.

3 TEST POINTS (TP) - V2.0

3.1 FOR ALL TYPES

TP1	Internal Mode delivered current (NS 232 & NS272 Only)	Iset × 221Ω (Volts)
TP2	Internal Mode D/A output (NS272 & NS232 Only)	Iset × 221 Ω (Volts)
TP7	+VREF the A/D reference	2.375 to 2.625 V
TP8	+VBAT the battery voltage	28 to 48 V
TP10	0 V circuit common	
TP11	+VDD the CMOS logic supply	14 to 16 V
TP12	Microcontroller Reset signal	
TP13	Microcontroller Interrupt signal	
TP14	System clock	100 Hz
TP15	+VCC the microcontroller supply	2.6 to 4.5 V

3.2 FOR NS272, NS252 & NS242

TP3	High Voltage Rail	420 V ±10%
TP4	External Mode delivered current	Iset × 13 Ω (Volts)
TP5	External Mode D/A output	Iset × 13 Ω (Volts)
TP6	Q10 gate voltage	

4 SELF TEST - V2.0

The unit has a built in Self Test Routine. At the start of the Self Test there must be no loads connected to the stimulator.

For NS272

The Self Test is initiated by holding down the Current Down, TET and PTC buttons while turning the unit on. The unit responds by displaying the ROM version number, '2.0', with a flashing target.

For NS232

The Self Test is initiated by holding down the Current Down, TW, 1 SEC TW, MUTE while turning the unit on. The unit responds by displaying the ROM version number, '2.0', with a flashing target.

For NS242, NS252

The Self Test is initiated by holding down the Current Down, TET and TW buttons while turning the unit on. The unit responds by displaying the ROM version number, '2.0', with a flashing target

4.1 ROM TEST (FOR ALL TYPES)

When any button is pressed, the unit beeps and displays a flashing 'CrC' for about 10s. Then all segments of the display light with a flashing target.

4.2 DISPLAY TEST* (FOR ALL TYPES)

When any button is pressed the unit beeps and the top row segments light with a flashing target. Each of the remaining three rows also light when a button is pressed.

4.3 MODEL TEST (FOR ALL TYPES)

After the fourth row of LCD segments has been lit the Model number, e.g. '272', is displayed with the flashing target.

4.4 BUTTON TEST (FOR ALL TYPES)

When the Model number is displayed only the Current Up button may be pressed. The unit beeps and displays a '1' with a flashing target. At this point only the Current Down button may be pressed. The unit beeps and displays a '2' with a flashing target. That number should increment as each of the remaining buttons is pressed in the following order:

Number displayed after button is pressed	NS272	NS252	NS242	NS232
3	TW	TW	TW	TW
4	TOF	TOF	TOF	1 Sec TW
5	TET	TET	TET	MUTE
6	DBS	DBS	1 Sec TW	RUN
7	PTC	PTC	12 Sec TOF	PROG
8	RUN	RUN	MUTE*	
9	PROG	PROG		
10	1 Sec TW	1 Sec TW		
11	12 Sec TW	12 Sec TW		
12	EXT	MUTE*		
INTERNAL	MUTE			

*A number will not be displayed, but go to external current test

4.5 INTERNAL MODE CURRENT TEST (NS272 & NS232)

After the Mute button is pressed the unit displays flashing INTERNAL. A 1 kΩ load must be connected to the Internal Mode Output of the unit which will then deliver continuous Internal Mode pulses at 10.0 mA. The output waveform should be observed on an oscilloscope.

When a button is pressed the unit delivers continuous Internal Mode pulses at 0.2 mA. The output waveform should be observed on an oscilloscope.

If the unit is an NS232, pressing any button then causes the unit to power as normal

4.6 EXTERNAL MODE CURRENT TEST (NS272, NS252 & NS242)

The load should be removed from the Internal Mode Output and a 1 kΩ load should be connected to the External Mode Output of the unit. When a button is pressed the unit will deliver 5 s bursts of 100 Hz External Mode pulses continuously at 160 mA. The output waveform should be observed on an oscilloscope.

When a button is pressed the unit delivers 5 s bursts of 100 Hz External Mode pulses continuously at 5 mA. The output waveform should be observed on an oscilloscope.

Pressing any button causes the unit to power up as normal.

5 ERROR CODES - V2.0

Throughout normal operation and the Self Test the microcontroller is constantly monitoring its internal operations. If it discovers something wrong it clears the display, lights the ERROR indicator, displays an Error Code and then shuts down. This process may not detect every possible failure but the Error Code will give some assistance in Fault Diagnosis. These codes are as follows:

Code	*Description*
00	T2 Overflow
01	Capture Interrupt
02	Missed Tick
03	Key Number Calculation Failure
04	RAM Failure
05	Button down in FIRST routine
06	Keyboard Failure
07	Voltage References out of Spec.
08	Undefined Model Number
09	Invalid Button Command in EXTMLOOP routine
10	Assembly Error in EXTMLOOP routine
11	Keyboard Error in EXTMLOOP routine
12	No I²C Acknowledge
13	I²C Bus not cleared
14	External Current Leakage
15	Internal Current Leakage
16	No EOP found in External Program
17	Assembly Error in Step Table in External Program Execution
18	Most Sig. Timeout Step Encountered First in External Program
19	Invalid Button Command in External Program Execution
20	Assembly Error in Button Table in External Program Execution
21	Keyboard Error in External Program Execution
22	External Programming Option Key Error
23	Invalid Button Command in External Program Programming
24	Assembly Error in External Program Programming
25	Keyboard Error in External Program Programming
27	Invalid Button Command in Internal Main Loop
28	Assembly Error in Button Table in Internal Main Loop
29	Keyboard Error in Internal Main Loop
30	No EOP found in Internal Program
31	Invalid Program Step in Internal Programming
32	Invalid Button Command in Internal Program Execution
33	Assembly Error in Internal Program Execution
34	Keyboard Error in Internal Program Execution
35	Invalid Button Command in Internal Program Programming
36	Assembly Error in Internal Program Programming
37	Keyboard Error in Internal Program Programming
38	Faulty LV Rail
39	CRC failure
40	Keyboard Failure
41	Faulty Internal Mode Output Socket
42	PC out of bounds MB0

Note For NS242 Only:
After TET is pressed an arrow ◄ will appear on the bottom left corner of the LCD, this is not an error or error code and it should be ignored

6 SERVICE INFORMATION (FOR ALL TYPES) - V2.0

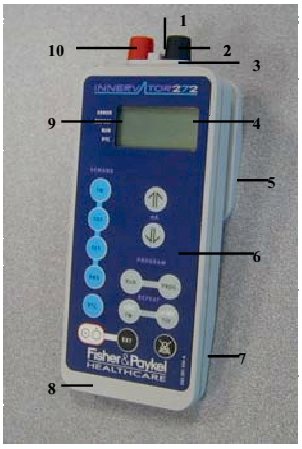
Disassembly/assembly is very straight forward. The battery cover simply unclips and there are two screws holding the case and PCB together. For NS272Bxx models there is a screw through the battery cover which must be removed.

Servicing should also be straight forward. The self-test in conjunction with an oscilloscope scan of the test points should narrow any fault to a particular block of hardware.

It is recommended to perform servicing check every year.

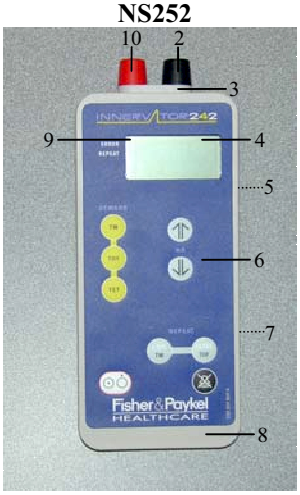
Component level servicing of the circuit board is not recommended. Contact the manufacturer for repair/replacement options.

7 PART LIST - V2.0

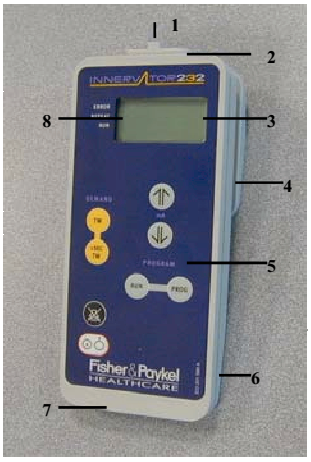


NS272

NS252



NS242



NS232

7.1 FOR ALL TYPES

614040219	Battery Screw
999840009	Battery Clip Single
999840007	Battery Clip Double
426040012	Beeper
349040081	Push Button
383040121	Transformer
614040157	Case Screw
185042351	Operating Manual – NS272
185042350	Operating Manual – NS252
185042349	Operating Manual – NS242
185042306	Operating Manual – NS232
043041024	NS272 PCB Kit (For shrouded socket models)
	Note: Non shrouded PCB no longer available
043042557	NS252 PCB kit (V2.0)
043042556	NS242 PCB kit (V2.0)
043042080	NS232 PCB kit (V2.0)
043042936	NS252 Front Fascia Assembly
043042937	NS242 Front Fascia Assembly
043042037	Kit shrouded socket NS272
043041087	Kit shrouded plug upgrade kit NS242/252

7.2 FOR NS272, NS252 & NS242

1	341040522	Header 4 Way U-Strip Samtec
1	341040399	Socket Internal (2.5mm Audio) NS272 only
2	341040509	Socket External Type Black (Shrouded)
3	693040719	Case Connector Insert NS272 (Shrouded)
3	693040747	Case Connector Insert NS252, NS242 (Shrouded)
4	423040004	LCD NS272
5	693040486	Cover Battery
5	693040497	Cover Battery Drilled
6	233201594	Front Fascia Panel NS272
6	233201601	Front Fascia Panel NS252 (V2.0)
6	233201600	Front Fascia Panel NS242 (V2.0)
7	693040698	Case Back
7	693040498	Case Back Drilled
8	693040697	Case Front
9	693040447	Window LCD Lens Cover
10	341040508	Socket External Type Red (Shrouded)

7.3 FOR NS232 ONLY

1	341040522	Socket Internal (Shrouded 4 pin socket)
2	694042032	Case Connector Insert 232 Safety
3	423040004	LCD NS272
4	693040486	Cover Battery
4	693040497	Cover Battery Drilled
5	233201588	Front Fascia Panel
6	693040698	Case Back
6	693040498	Case Back Drilled
7	693040697	Case Front
8	693040447	Window LCD Lens Cover

8 ACCESSORIES - V2.0

8.1 FOR ALL TYPES

200NS002	Carry Case
900MR030	Fixed Pole Clamp
200NS009	Bracket
900MR170	C-Clamp
900MR820	Wall Mounting Bracket

8.2 FOR NS272, NS252 & NS242

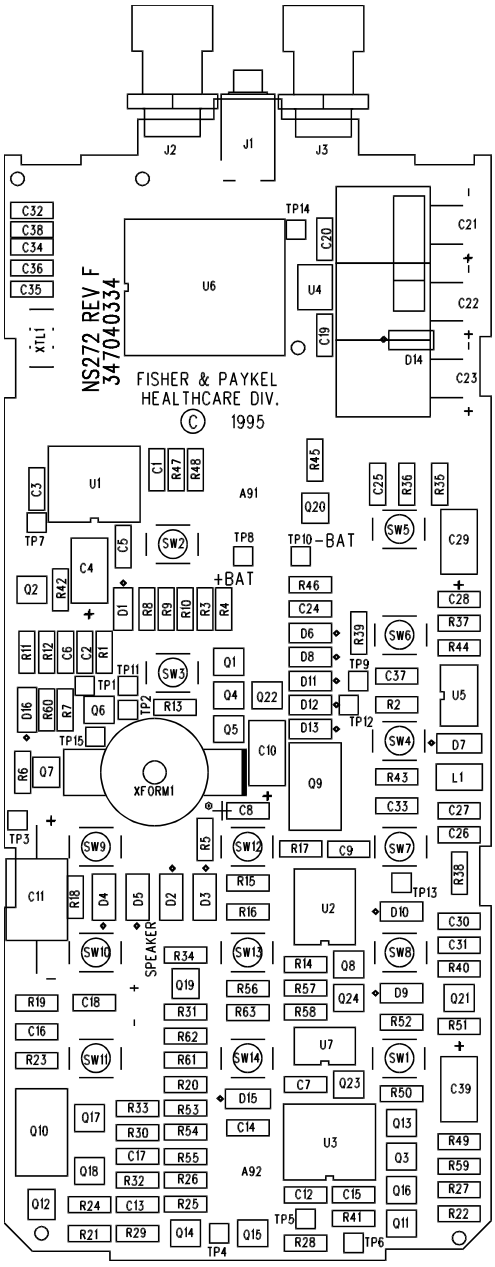
200NS030	Diagnostic Probe (Ball Electrodes), Shrouded Disposable (Box of 20)
200NS003	Dual Electrodes (Disposable)
200NS037	External Mode Leadset, Shrouded, for disposable electrodes (Alligator/Alligator) 2.0m
200NS031	External Mode Leadset, Shrouded, for disposable electrodes (Alligator/Alligator) 1.5m
200NS032	External Mode Leadset, Shrouded, for reusable electrodes (Pin/Pin) 1.5m
200NS033	External Mode Leadset, Shrouded, for disposable electrodes (Dome/Dome) 1.5m

8.3 FOR NS272, NS232

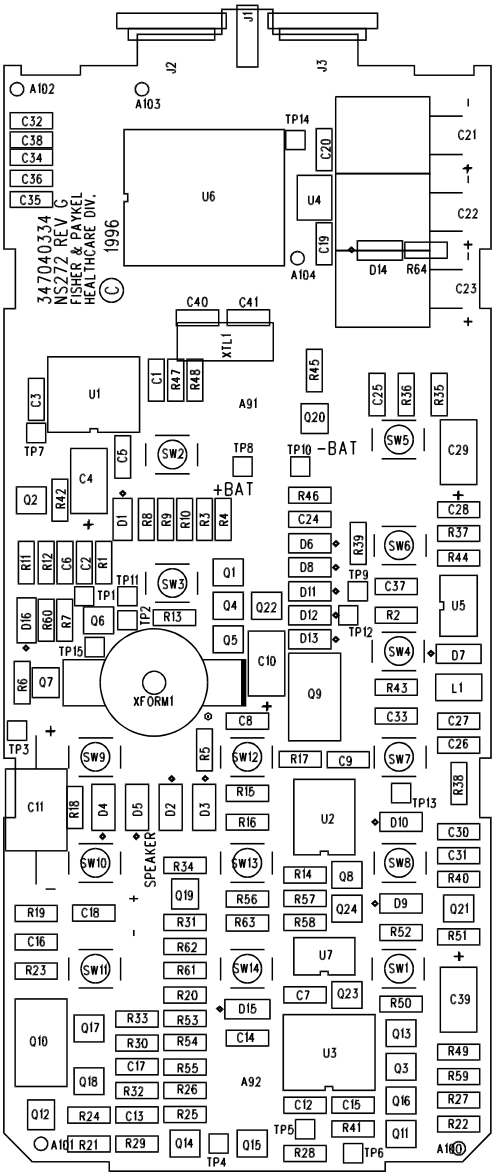
200NS034	Internal Mode Leadset, Shrouded, for disposable electrodes (Dome/Alligator)
200NS035	Internal Mode Leadset, Shrouded, for reusable electrodes (Pin/Alligator)
200NS036	Internal Mode Leadset, Shrouded, for disposable electrodes (Dome/Pin)

8.4 COMPONENT LAYOUT DIAGRAM

Non Shrouded (For NS272, NS252, NS242 with non-shrouded plug)



Shrouded (For NS272, NS252, NS242 with shrouded plug and NS232)



Appendix A PRODUCT CHANGE HISTORY (FOR NS272, NS252, NS242) - V2.0

This change history details changes, which may have significance for servicing. It may not include all changes. Refer also to change panel on circuit diagrams.

Date	Change number	First serial number affected	Comments
24/5/95	2268	9527AUU02443	Change NS272 to Rev F PCB.
5/8/96	2796	9627JUU00837	Change NS272 to Rev G PCB which includes Shrouded socket.
19/11/03	6857	031202001629	Use new EPROM V2.0 PCB on NS242
19/11/03	6857	031202001627	Use new EPROM V2.0 PCB on NS252

Appendix B PRODUCT NUMBERS (FOR ALL TYPES) - V2.0

This section explains how the part number is deciphered. The model number refers to a specific variant while the serial number individually identifies the manufactured item. The model number and serial number collectively form the product number.

B1. MODEL NUMBER EXPLANATION

e.g. for NS272AUU:

NS272	A (first letter)	U (second letter)	U (third letter)
Model Type	Regulatory	Customer	Special Features

B2. SERIAL NUMBER EXPLANATION

e.g. for 9627AUU03789:

Year	Model Number Abbreviation	Code	Serial Number
96	27 (= NS272)	AUU	03789

The three-letter code (eg AUU) is defined above.

From year 2000 onward the serial number has a different format.

e.g. for 2000-23AUU01234:

Year	Model Number Abbreviation	Code	Serial Number
2000	23 (= NS232)	AUU	01234

The three-letter code (eg AUU) is defined above.

From 29/6/2001, all barcodes used were switched to EAN/UCC 128 Barcode format which is a international recognized format. An example of the barcode is:

(01) 094 200124 0971 3 (21) 010417123456

There are 30 digits in total. In the actual barcode, there are no () and spaces.

Digit	**Meanings**
()	Application Identifiers
01	Primary Identifier (Header) for manufacturing details. It is always 01 in all our product
0	Logistic unit always 0
94	Country code for New Zealand
200124	F&P Company Code
0971	The product code
3	Checksum which is generated automatically by the labelling program. The bar code reader will also check this number. This means that if barcode is not valid, the barcode reader will not read that into the keyboard buffer
21	Secondary Identifier (Header) for serial number to follow.
010417	6 digit date in the serial number. 01 is 2001, 04 is April, 17 is the day.
123456	This is the serial number of the product

The primary ID, secondary ID and the length of the serial number will also be checked.

B3. PRODUCT CODE TABLE

Product	Product Code
NS232AUU	1074
NS242AUU	1075
NS252ALN	1076
NS252AUU	1077
NS272AUU	1078
NS272BUU	1079
NS272ABA	1128

TECHNICAL MANUAL

NS242

NS252

VERSION 1.0 & 1.1

CONSTANT CURRENT

PERIPHERAL NERVE STIMULATOR

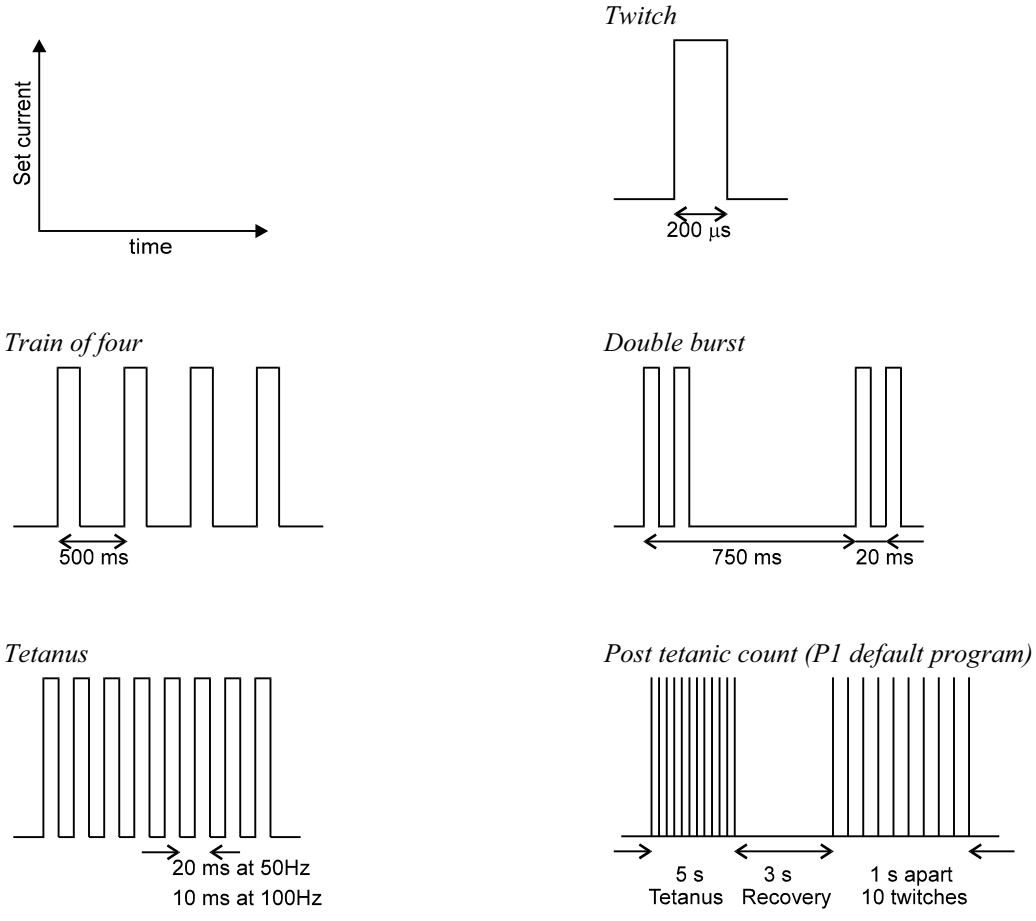
1 GENERAL SPECIFICATIONS – V1.0/V1.1

This part of the manual defines the technical specifications for the NS252 & NS242 Peripheral Nerve Stimulator with version 1.0 or 1.1 software.

1.1 ELECTRICAL SPECIFICATIONS – V1.0/1.1

Output Current Range:	0 - 80 mA for the NS242. 0 - 160 mA for the NS252		
Output Pulse Type:	Square, monophasic constant current		
Output Pulse Width:	200 ± 5 µs		
Output Pulse Rise Time:	5 µs max (resistive load)		
Output Pulse Fall Time:	5 µs max (resistive load)		
Output Voltage:	(up to) 350 V		
Maximum Load Impedance at 80 mA:	For TW, TOF,DBS	for TET	
	4 kΩ	3.5kΩ	
Maximum Load Impedance at 160 mA:	For TW, TOF	for TET	for DBS
	2kΩ	1.2 kΩ	1.5 kΩ
Battery Type:	3 of 1.5 V AA type alkaline cells (IEC type LR6)		
Battery Life:	>300 hours continuous use		

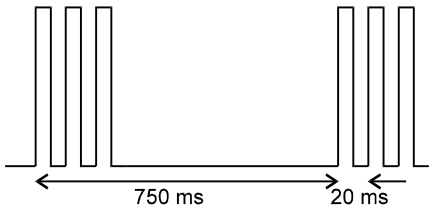
1.2 PULSE TYPES: ROM 999630013



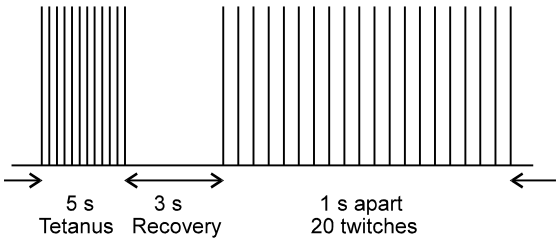
1.3 PULSE TYPES: ROM 367020009

The pulse trains delivered using this ROM are the same as above except for the following:

Double burst



Post tetanic count



2 HARDWARE DESCRIPTION – V1.0/1.1

2.1 CONTROL

The core of the system is an 84C42 microprocessor U1 which communicates via an i²c bus serial interface to an 8577 display driver U5 and an 8591 A/D, D/A converter U4. The push-buttons are arranged in a row/column scanning matrix with a diode-or connection causing any button press to generate an interrupt on pin 9 of U1. The on/off button causes a short reset pulse to be issued to U1 via C5. There are two voltage rails generated under microprocessor control: a 12 V rail, used for switching FET's and generating a reference for the A/D, D/A converter, and a 350 V rail for pulse delivery.

2.2 REFERENCE RAIL

The 12 V nominal reference rail is controlled by pin 5, U1, active high. It is generated by U2, a Maxim 4193 DC-DC converter configured in a boost mode. The voltage divider R7, R8 and R9 sets pin 7 at the feedback control voltage of 1.31 V. C8 sets the oscillation frequency at 40 kHz nominal. TR1 in conjunction with R10, R11 and R12 sets the A/D, D/A reference at 2.5 V nominal.

2.3 HIGH VOLTAGE RAIL

The high voltage rail is a 1 µF, 450 V electrolytic capacitor, C18, charged to the lesser of 350 V or the set current times 5000 Ω, and controlled by U1. To charge the rail, U1 first activates the 12 V rail, which powers U3 and thereby TR3. U1 then activates the U3 oscillator by releasing the U3 reset pin via U1 pin 15, active high. U3 then oscillates at 50 kHz nominal set by R15, R16 and C12. TR3 switches the primary of transformer 1. The full wave bridge on the secondary consisting of D4, D5, D6 and D7 acts as a voltage doubler, and via tight transformer coupling serves to limit the fly-back voltage effect on the primary to approximately twice Vbatt. U1 will only charge C18 for 5 ms then wait 15 ms at a time to prevent excessive battery load or voltage droop. The rail is monitored and controlled by U1 via pin 1 of U4 the A/D converter.

2.4 CONSTANT CURRENT CONTROL

U1 sets the constant current to be delivered by a set voltage on pin 15, the analogue out channel of U3 corresponding to the set current via the relationship:

Analogue volts out = set current × 13 Ω

The differential transistor pair, TR7 and TR8 will now attempt to maintain this voltage at the emitter of TR8 once they have been enabled by U1 pin 19, active low and TR4. R33 serves to balance TR8 to TR7. The constant current pulse can now be delivered by turning on TR6, via TR5 and U1 pin 4, active low. R30 acts to limit short circuit current and in conjunction with C19 limits damaging dv/dt to the FET TR6. The actual current delivered is also read and processed by U1 by making an A/D reading mid-pulse of the voltage across R35. C20, C21 and C22 aid high frequency noise suppression generated by oscillators.

2.5 LOW BATTERY DETECT

This works in two stages. First T1, pin 11 of U1 will go low if LBR pin 1 of U2 drops below 1.31 V. When this happens U1 will light the low battery indicator and V_{cc} = 2.8 V nominal. U2 must have been activated at pin 6 for the output at pin 8 to be valid. U1 will then monitor the battery voltage via A/D channel 2, pin 3 U3. When this drops to V_{cc} = 2.6 V nominal U1 will blank the displays apart from the low battery indicator, and will cease to function further until the batteries are changed. The unit must be turned off and on for U1 to recognize this has occurred.

2.6 MISCELLANEOUS

The beeper is driven by a standard astable multivibrator circuit centered around TR11 and TR12. The digital hardware is run off a diode isolated supply V_{cc} to prevent any damage due to reverse insertion of batteries. C16 and C17 help to minimise any adverse battery voltage drops.

3 OPERATIONAL DESCRIPTION – V1.0/1.1

3.1 POWER DOWN

When powered down the processor will complete an orderly power down sequence and then will monitor the high voltage rail. Once it has dropped to under 2V then TR6 will be turned on to conserve battery life. TR9 prevents any leakage to the electrodes.

3.2 SELF CALIBRATION

The unit self-calibrates by first activating U2 then measuring the reference voltage at pin 7 U2 (1.31 V) via pin 4 U4, the A/D converter. This occurs each time the unit is powered up, and all A/D, D/A readings are adjusted accordingly.

3.3 PULSE DELIVERY

To deliver a constant current pulse the following sequence of events occurs:

U2 is turned on.

C18 is charged up to the appropriate voltage.

Analogue out pin 15 U4 is set to the corresponding set current.

U1 pin 19 goes low, turning on TR9, and supplying the differential pair TR7, TR8.

U1 pin 4 goes low, initiating current delivery.

Beeper turns on.

Voltage across R35 is read.

U1 pin 4 goes high, terminating the 200 µs pulse.

U1 pin 19 goes high.

Analogue out turns off.

Beeper turns off after 10 ms.

U2 is turned off.

Tetanus delivery is similar, except that U2 is left on and the high voltage rail is turned on for 5 ms only, immediately following each delivered pulse.

4 TEST POINTS – V1.0/1.1

TP1 high voltage rail

TP2 current delivered across 13 Ω

TP3 current control feedback signal 0 to 12 V

TP4 i²c clock

TP5 i²c data

TP6 set current control analogue out

TP7 Vsw, nominal 12 V rail

TP8 Vref, nominal 2.5 V rail

TP9 Vbatt, battery voltage

TP10 V_{cc}, battery voltage minus diode drop

TP11 0 V

5 SELF TEST – V1.0/1.1

5.1 ROM 999630013

The self test mode is entered by simultaneously depressing the TW, TOF and CURRENT UP buttons then powering the unit up. The following sequence is then executed:

1) Displays 00 mA. Beep sounded.

2) Display test

- all segments.
- seven segment rotate.
- special purpose annunciators.

3) Button test - the display blanks and then displays the scan code as follows for 14 button presses:

01	TW
02	Current up
03	TOF
04	TET
05	Current down
06	10 s TW
07	12 s TOF
08	P1
09	P2
10	DBS
11	PROG
12	Mute
13	1 s TW

4) The nominal reference of 1.31 V on pin 7, U2 is measured by the A/D as a cross reference to the A/D reference. If it is out of limits ER3 is displayed.

5) C18 is charged to 350 V and the time taken is tested. If it is longer than 500 ms ER1 is displayed.

6) Leakage current with C18 at 350 V and TR6 and TR9 off is measured. If it is greater than 1mA ER4 is displayed.

7) 160 mA tetanus is delivered for 5 seconds. If the load resistance is greater than 2000 Ω then the fault indicator will appear.

8) 10 mA tetanus is delivered for 5 seconds.

9) The displays are blanked and all annunciators are turned on. The unit remains in this state until it is turned off. However at this stage the following tests may be carried out:

a) When the supply voltage is lowered to 3.4 V the low battery indicator should appear.

b) When the supply voltage is lowered further to 3.2 V the display should flash LO and then blanks, the unit having entered the powered down state.

5.2 ROM 367020009

The self test mode is entered by simultaneously depressing the TW, TOF and CURRENT UP buttons then powering the unit up. These buttons must be held until step one below begins:

1) Displays 00 mA, beep sounded.

2) Display test - seven segment rotate.

   - special purpose segments.

3) Button test - the display blanks and then displays the scan code as follows for 14 button presses:

   01 TW

   02 TOF

   03 TET

   04 DBS

   05 Current Up

   06 Current Down

   07 RUN

   08 PROG

   09 1 s TW

   10 10 s TW

   11 12 s TOF

   12 PTC

   13 Mute

4) This step and the following are exactly as per ROM 999630013.

6 SERVICE INFORMATION – V1.0/1.1

Disassembly/assembly is very straight forward. The battery cover simply unclips and there are two screws holding the case and PCB together. For NS2X2B models there is a screw through the battery cover which must be removed.

Servicing should also be straight forward. The self-test in conjunction with an oscilloscope scan of the test points should narrow any fault to a particular block of hardware.

It is recommended to perform servicing check every year.

Component level servicing of the circuit board is not recommended. Contact the manufacturer for repair/replacement options.

7 PARTS LIST – V1.0/1.1

Please note that PCB Assembly, Front Fascia Label, Operating Manual, LCD of NS252 and NS242 of software V1.0 and V1.1 are no longer available for ordering.

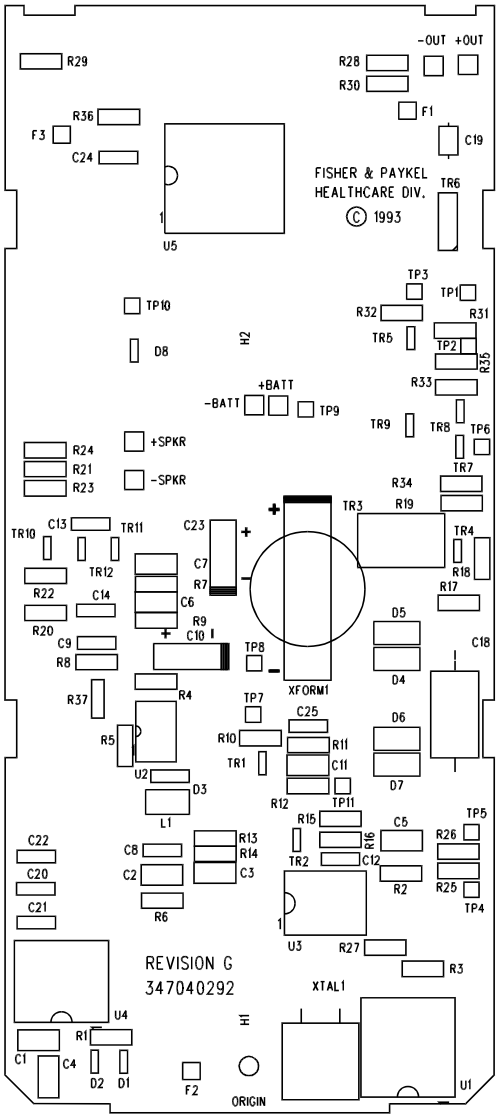
For other parts, please refer to Section 7 Part List - V2.0 on page 19.

8 ACCESSORIES – V1.0/1.1

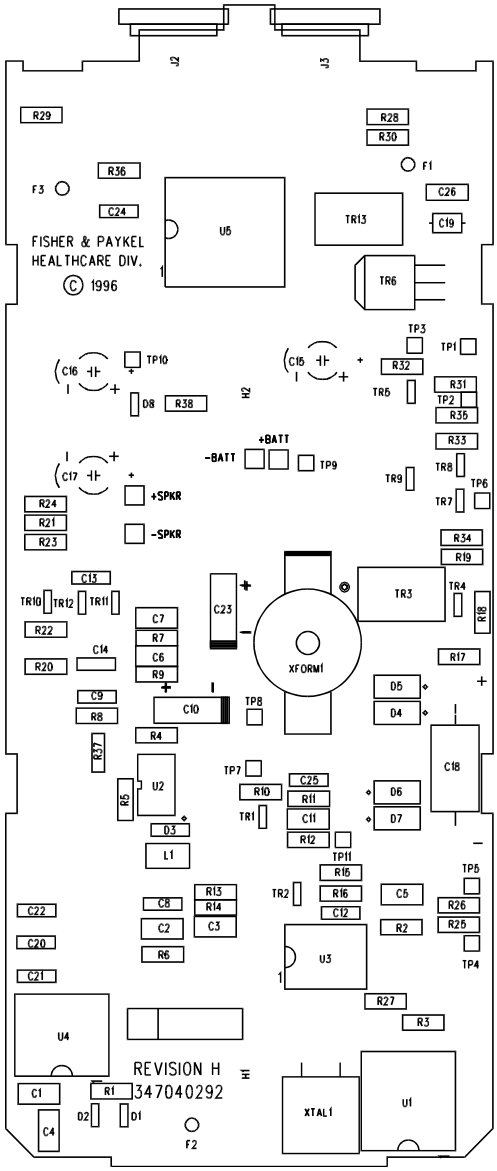
Please refer to Section 8 Accessories - V2.0 on page 20.

8.1 COMPONENT LAYOUT DIAGRAM

Non shrouded (rev G)



Shrouded (rev H)



Appendix A SERVICE NOTE – V1.0/1.1

Applies to units using 999630013 ROM (Version 1.0).

The reference voltage to the 8591 AD/DA converter is generated by inexpensive low tolerance components. To maintain accuracy the stimulator self-calibrates all the AD/DA readings to a 1.31 precision voltage, available elsewhere in the design.

An AD reading of the 1.31 V is made, and then this count is used to calculate what the 8591 reference really is. All other readings and delivered currents are then adjusted with this knowledge.

This allows the "reference" voltage to be anywhere from 2.3 to 2.8 V, yet all readings and current delivery are still accurate.

One part of the self test is to read and calculate what the reference voltage really is. This is stored to use later in the 160 mA and 10 mA tests. First the reference is checked and if it is outside the range 2.3 to 2.8 the unit will halt and display ER3.

There is a software error in the ROM which affects the SELF TEST ONLY.

It may cause the reference voltage to sometimes be calculated incorrectly, it all depends exactly when you take your finger OFF the last (14th) button press in the button test.

If the miscalculation occurs it will always cause the reference to be calculated LOWER than it should be, exactly how much lower may vary. This means delivered current will be HIGHER. The effect is worse for higher currents. Thus the 160 mA self test may have to be disregarded but the 10 mA self test should not be. The 160 mA test then has to be done manually by delivering 160 mA tetanus.

There is another manifestation of the same software error. If the tested unit happens to have a reference near 2.3 V, AND if the miscalculation occurs, the ROM may think the reference is less than 2.3 V and fail with ER3. However in this case the unit is not faulty.

Appendix B PRODUCT CHANGE HISTORY – V1.0/1.1

This change history details changes which may have significance for servicing. It may not include all changes. Refer also to change panel on circuit diagrams.

Date	Change Number	First serial number affected	Comments
25/06/91	0642	91250123 91240135 91250149-174	NS252A: Introduction of ROM Version 367020009. NS252J NS252A: ROM Version 999630013 used.
5/8/96	2796	9624AUU0506	NS242: Introduction of Rev H PCB & shrouded plugs
26/9/96	0493	9625BUU0867-899	NS252: Produced units with non-shrouded plugs

Appendix C PRODUCT NUMBERS – V1.0/1.1

This section explains how the serial number appearing on the product is deciphered. The model code refers to a specific variant while the serial number individually identifies the manufactured item.

C1. MODEL NUMBER AND SERIAL NUMBER EXPLANATION

For all NS242 and NS252 units produced **before 01/01/93**

eg 92DB3423 represents:

Year	Model Number Abbreviation	Serial Number
92	DB	3423

Model	Model Number Abbreviation	Country
NS242A	DA	NZ/Canada/Europe
NS242J	DB	USA
NS242D	DC	France
NS242B	DD	Germany
NS242JW	DE	USA
NS242JAW	DF	USA
NS252JA	22	USA Only (V1.0)
NS252AA	23	NZ/Canada/Europe (V1.0)
NS252J	24	USA Only (V1.1)
NS252A	25	NZ/Canada/Europe (V1.1)
NS252D	26	France
NS252JW	27	USA
NS252B	28	Germany
NS252BW	29	Germany

For all NS242 and NS252 units produced **after 01/01/93.**

eg for NS252AUU:

NS252	A (first letter)	U (second letter)	U (third letter)
Model Type	Regulatory	Customer	Special Features

The model number typically appears with the serial number.

eg for 9625AUU03789:

Year	Model Number Abbreviation	Code	Serial Number
96	25 = NS252 (24 = NS242)	AUU	03789

From 29/6/2001, all barcodes used were changed to EAN/UCC 128 Barcode format which is an international recognized format. An example of the barcode is

(01) 094 200124 0971 3 (21) 010417123456
There are 30 digits in total. In the actual barcode, there are no () and spaces.

Digit	Meanings
()	Application Identifiers
01	Primary Identifier (Header) for manufacturing details. It is always 01 in all our product
0	Logistic unit always 0
94	Country code for New Zealand
200124	F&P Company Code
0971	The product code
3	Checksum which is generated automatically by the labeling program. The bar code reader will also check this number. This means that if barcode is not valid, the barcode reader will not read that into the keyboard buffer
21	Secondary Identifier (Header) for serial number to follow.
010417	6 digit date in the serial number. 01 is 2001, 04 is April, 17 is the day.
123456	This is the serial number of the product

The primary ID, secondary ID and the length of the serial number will also be checked.

C2. PRODUCT CODE TABLE

Product	Product Code
NS232AUU	1074
NS242AUU	1075
NS252ALN	1076
NS252AUU	1077
NS272AUU	1078
NS272BUU	1079
NS272ABA	1128